Industrialisation in construction

Multiple actors, multiple collaborative strategies

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Abstract

This paper examines industrialisation strategies followed by different actors of the construction industry: a client, a small builder of individual houses and a large contractor associated with a company developing and selling home furnishing. In the paper cooperation is considered as a form of process industrialisation. The economic literature usually distinguishes between two types of collaborative agreements: contractual and relational. Contractual elements provide guarantees. Relational factors bring trust and tend to favour learning among actors. The three case studies focus on collaborations during the course of these projects. They reveal that collaboration is never purely formal or relational. There is always a mix of contractual and relational governance mechanisms. Collaboration becomes more contractual once the concepts come closer to the market stage. At the R&D phase, cooperation tends to be more relational to promote trust and learning among partners.

Keywords: industrialisation, collaboration, innovation, contracts, relations

1. Introduction

The building and construction industry is often perceived as a laggard for innovation compared with other industries. The fragmentation of the industry, the procurement process mainly based on tendered price and the conservatism of employees of the building site are often put forward to explain this situation. But the construction industry is also looking for new methods, approaches and tools that will improve its performance (Brousseau and Rallet, 1995). Industrialisation, prefabrication, concurrent engineering, supply chain management, clients' participation have been considered as ways for the industry to improve its practices.

During the period following World War 2 several initiatives were launched to promote industrialisation in construction. In France these attempts resulted from the demand of the State that guaranteed the construction of thousands of social housings. But industrialisation has not been as successful and widespread as in other industries. In most Western countries the uptake of industrialisation and off-site manufacture is limited. The needs for diversity, the heterogeneity of the demand, the change of the demand during the course of a project, the resistance of the workforce on the building site, are barriers to the development of these approaches.

According to Davies and al. (2009), construction projects are ranging from unique megaproject to standardised one. The aim of this article is to focus on one side of the spectrum (the standardised projects) and to examine the process that allows industrialisation and to present which collaborative strategies were developed by the actors involved in those projects.

The second and third sections define industrialisation and explain how relational and contractual governance mechanisms are influencing collaboration. The following section draws upon three case studies: A French builder, a client working worldwide in the hospitality industry and a joint-venture made up an international contractor and a company developing and selling home furnishing worldwide. Results are discussed in a concluding section.

2. Industrialisation in the construction industry

The range of stakeholders working in the construction industry is broad. Construction cannot be limited to the definition given by the International Standard Industrial Classification (ISIC). It comprises not only the creation, renovation, repair or extension of buildings and engineering constructions but also upstream (manufacturing), parallel (architectural activities and technical consultancy) and downstream activities (facility management). All these actors are concerned by industrialisation but at different levels (Sexton and al., 2007).

The concept of industrialisation mainly concerns the suppliers of the construction industry who provide standardised and industrialised products. The model of product and process innovation developed by Utterback and Abernathy (1975) indicate that once a dominant design is established then the efforts in the industry focus on rationalisation and on process innovation to reduce cost and

improve productivity. Industrialising the process is a way to rationalise it and to reduce production costs.

At a first glance the activity developed by architects and technical consultant is not industrialised. But even their activity can be standardised. As mentioned by Drejer (2004, pp557), the fact that "every service delivery is unique" is misleading and does not mean that every service is new. Services are mode of elements that remain unchanged and elements subject to developments.

Similarly construction project can be more or less standardised according to product and process standardisation. "*Product standardisation depends on the extent to which a client specifies a one-off outcome. Process standardisation depends on the extent to which tasks and components can be simplified and repeated*" (Davies and al., 2009, pp105). At one extreme routine projects are based on repetitive tasks and provide standardised outcome. At the opposite a unique project can require non-routine processes. Most projects lie within this range and "*involve a combination of standardised and customised elements*" (idem, 105). This also means that a unique project can be achieved by using standardised processes.

According to Alinaitwe et al. (2006), there are several ways to consider industrialisation in construction.

The first is to distinguish between on-site and off-site industrialisation:

- Off-site industrialisation refers to pre-fabrication of building elements that will be assembled on site. It can offer numerous benefits such as a decrease of trades and interfaces to manage and coordinate on site, better working conditions, better control and more consistency, a fall of waste on and off site (Blismas, 2007).

- "*On-site industrialisation refers to the application of advanced tools and technologies on building sites*" (idem, 2006, pp222). Just in time deliveries or identification of elements with bar codes are examples of on-site industrialisation.

The second option is to separate product industrialisation from process industrialisation. "*On-site and off-site are both examples of product industrialisation. On the other hand, process industrialisation is concerned with how parties are cooperating, contractually and informally."* (idem, pp222).

3. Cooperation and construction

As it was aforementioned, cooperation is a form of process industrialisation. It is a way to have access to closely complementary and dissimilar activities (Richardson, 1972). It is sought when ex-ante co-ordination between different phases of production is necessary. These collaborative relationships can take a hierarchical form. According to the transaction cost economics, parties tend to apply legal contracts in order to safeguard against the hazard of opportunism. Hybrid forms such as cooperative

agreements are suited when asset specificity is intermediary, transaction neither recurrent nor occasional (Williamson, 1991). However contract can never stipulate every potential contingency. This is particularly the case with complex project. Complex performance contracts are usually incomplete and excessively detailed. Thus they may be difficult to enforce (Lewis and Roehrich, 2009).

Conversely the relational perspective focuses on the role of trust. When trust replaces uncertainty and opportunism, informal obligations may constitute a more stable framework for interaction and learning (Lundvall, 1988). It promotes solidarity and information exchange. Informally it facilitates the enforcement of obligations. Dealing with interorganisational learning capacities, Lundvall (1993) introduces the concepts of technical, communicative and social learning and technical learning:

1. Technical learning exists when interaction between users and producers induces an understanding of reciprocal needs.

2. Communicative learning involves the establishment of technical codes, tacit and specific to the partners.

3. Social learning limits opportunism by creating similar behavioural codes.

Relational and contractual governance mechanisms are also considered as complementary. Developing complex contracts require the development of social relations (Poppo and Zenger, 2002). Contractual safeguards work as a guarantee and provide incentives to the other party. It stimulates cooperation by proposing processes for adapting to change.

The construction industry is often criticised for its inability to cooperate and to learn from one project to the other. Winch (1998, p.271) mentioned for the UK "*the exploration trap where technologies are continually re-invented in a circular rather than progressive manner* (…)". Gann and Salter (2000) considered that construction firms tend to re-invent the wheel and to favour novelty rather than standardisation. Slaughter (1993) also indicated the problem linked to the duplication of effort that occurs among builders who use stressed-skin panel.

The fragmentation of the industry brings flexibility but it does not favour cooperative agreements. As indicated in the Egan (1998) report "*the extensive use of subcontracting has brought contractual relations to the fore and prevented the continuity of teams that is essential to efficient working.*" It also means that firms do not have any incentives to invest time in order to cooperate because of this discontinuity of teams.

4. The case studies

The results presented below are based on the work undertaken in the international collaborative project 'TRANSUSERS – transforming the construction sector through user-driven innovation'.

TRANSUSERS was carried out between 2007 and 2009. Two research centres from Denmark and France were involved in this project.

4.1 Selection and origin of the cases

Cases were selected in two countries: France and Sweden. Winch (2000) has stressed the importance of national construction business systems. Construction is an industry with centuries of tradition but it usually takes place in a national context. Design, site works, maintenance and operating always need to be accomplished but the relationships between the actors accomplishing these tasks will vary from country to country. Each country has its own business system. Winch distinguishes between three types of business systems:

- The Anglo-Saxon system is characterised by "*a greater reliance upon liberal market values, relatively low levels of state regulations….*" (idem, 90);

- The corporatist system depends more on « *negotiated coordination between the 'social partners', greater willingness to intervene in the market to protect social values…* » ;

- *The « étatique » system has more extensive coordination of the economy by the state relatively high level of worker protection … and a desire to promote national champions in various industrial sectors* ».

France and Sweden represent two different systems. The organisation of each system has a very strong influence on the diffusion of innovation. For example Boxenbaum and Daudigeos (2007) showed that the difference in the level of diffusion of prefabricated elements in concrete in France and Denmark resulted from the interaction of several factors: labour supply, path-dependency (experience in the use of concrete within enterprises), national Danish legislation promoting prefabricated elements (no similar preference in France) and the agency of professionals.

The cases will focus on different actors of the construction industry:

- A French builder specialised in low energy houses which develops new methods for manufacturing prefabricated elements;

- A client working worldwide developing a new approach to renovate its hotels;

- An international contractor and a company developing and selling home furnishing in the world who developed a new house concept.

Information was gathered through publications when available and mainly face to face interviews with the stakeholders of the projects.

4.2 Industrialisation in the hotel industry: the case of « hotelF1 »

With 3,871 hotels and 461,698 rooms, the group ACCOR covers every segment of the world hospitality market (90 countries), from budget to upscale. HotelF1 is the leader on the low-cost hotel segment. The 371 hotels are mainly located in France (282 hotels and 20,924 rooms). To be economically viable the low budget hotel chain was constructed according to an industrialised process. But this was possible because collaboration was established between the client and one contractor at the design stage. The joint use of contractual and relational mechanisms generated efficient results.

At the design stage a project team was constituted outside the traditional boundaries of the group ACCOR. This decision aimed at circumventing potential resistances which could have appeared within the group. This team collaborated with a contractor who had developed several concepts of prefabrication. The original proposal written by DUMEZ exceeded 50% the costs of objectives laid down by the project team (Ben Mahmoud Jouini and Midler, 1996). Consequently, a phase of co-operation began for the design of a prototype between this company and the project team in order to develop solutions which lower the initial costs of construction. A contract was signed between the two actors for fourteen months. But most of the time the client and the contractor went beyond their contractual agreement. The two partners rapidly trusted on another and worked with an open book approach. This information disclosure preserves the stability of the agreement and favours innovations[1] . Indeed the financial impacts of any new proposal were rapidly computed. The stake of the collaboration consisted in optimizing the design of the hotel in order to industrialise the construction process and to limit the future exploitation costs. Despite the six months spent at the design stage, the first prototype required 5000 working hours to be built. The goal of the client was laid down at 2500 hours. The optimisation which followed, contributed to lower the execution time to 3500 hours for the second prototype. For eight months a value analysis was developed within the project team and showed the economic viability of the project. The prefabrication of the sanitary block contributed to reduce the construction costs. The project team was also able to reach the construction cost which was initially targeted because all the people involved in the construction of the three first hotels were the same. This entails learning among partners. To avoid relying on a single contractor at the construction stage, group ACCOR worked with two other companies. But the initial contractor got 50% of the market (fig.1).

The first hotel was built in 1986. This industrialised approach which was defended by the project managers since the first stages of the project, contribute quickly to the development of the chain. It also prevented the reactions of possible competitor projects.

In 2003, the managers of the low-cost chain thought that it was necessary to adapt the brand to changes in the marketplace. This resulted from the fall of the occupancy rate. Consequently a

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[1] "*Because of the limited role of the price mechanism and of the uncertainties surrounding the appropriation of rent, information disclosure will be essential to the existence and stability of hybrid forms*" (Menard, p.159, 1996).

refurbishment of the hotel portfolio was launched in order to create a more contemporary room while still offering customers the lowest price in the market. The project aimed at redesigning rooms, the cafeteria and common areas, and reworking the brand's logo, signage ("Formule 1" is replaced by "hotelF1") and other aspects of its visual identity. Concurrent engineering was one of the key word of the renovation project. The length between the decision to renovate the hotels and the effective renovation of the first hotels helps the technical direction to improve its design, to ameliorate the supply-chain management and to optimise the process. For the renovations of the hotels long-term contracts (2007 – 2010) were signed between the technical direction of "hotelF1" and 10 selected contractors. It provides partners with opportunities to learn from one another. It also contributes to the establishment of common codes of information between partners. By providing the actors involved in the renovation project with an identical set of references, it favours communication, develops the stability needed for exchange and enhances the efficiency of coordination.

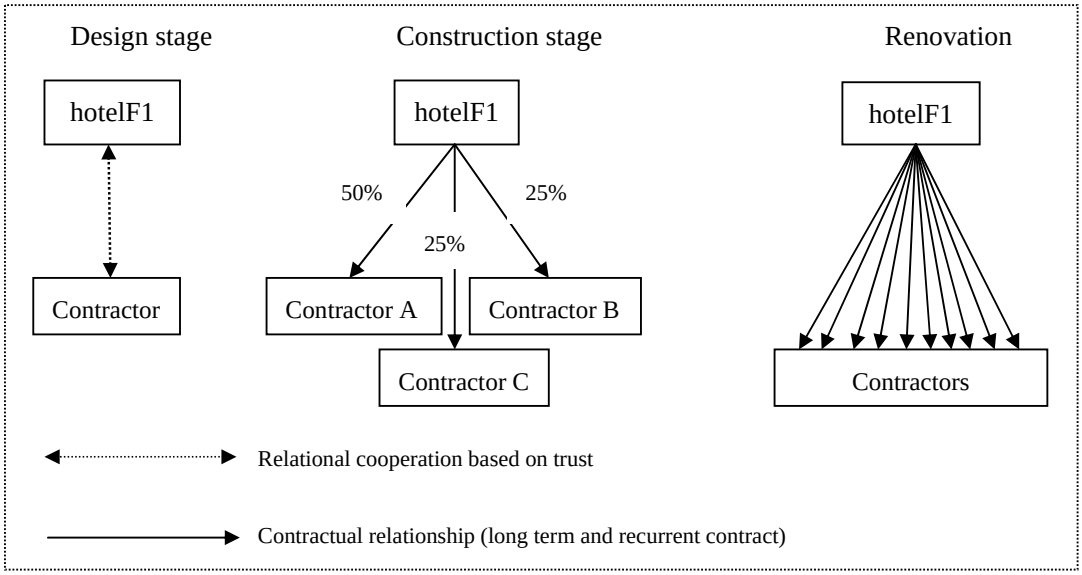

Figure 1: Nature of collaborative relationships between hotelF1 and its partners

Long-term planning (until 2010) results from the decision of the technical direction to adopt an industrialised approach. Construction is often characterised by the lack of continuity of teams that is essential to efficient working. This kind of framework agreements aims at tackling this problem and at improving efficiency and quality. In this case the standardization of the hotels of the F1 chain and the fact that most hotels were built at the same period, opened the opportunity for an industrialised renovation.

4.3 The prefabrication of individual houses

"Maisons MACCHI" is a family owned company, created in 1946 and employing 22 people. Specialized in the construction of houses, the company is characterized by its innovative approach

concerning a method for manufacturing prefabricated elements. It is certified ISO 9001: 2000 and can be considered as one of the leading company on the French market for low energy houses.

The prefabricated process “MACC3” which was patented by the entrepreneur gives the company a competitive advantage on the market of low energy houses. This process rests on a prefabricated insulation system. The expanded layer of polystyrene (from 30 to 50 centimetres of thickness) is provided by a leading manufacturer. It is pressed in freshly-mixed concrete. The prefabricated wall is also very innovative because it integrates heating tablecloths and plumbing networks.

The development of the innovation results from the know-how accumulated by the contractor during his career and from partnerships established with several actors of the construction industry. These collaborations are both based on formal and informal agreements.

A polystyrene supplier, leader in his field, is frequently solicited by the contractor to deliver new products which are integrated into the construction process. For example, in the first times of collaboration, polystyrene was delivered in modules of 1 m by 1.20 m. The contractor then asked his supplier to cut out polystyrene on his manufacturing unit in order to deliver a product that fits the features of the construction process.

After a failure with a local manufacturer who intended to imitate the constructive process a collaborative agreement was signed with a German manufacturer who is in charge of prefabricating the walls. This company does not fully master the realisation of the prefabricated walls. Consequently it still benefits from the technical assistance of one engineer and two employees of “Maisons MACCHI”. The aim of their actions is to check that the electric boxes are stuck to the good place and the insulation layer in polystyrene is well positioned.

A partnership is also engaged with a financial institution which grants loans with reduced interest rates (3.5% up to 50000 Euros to every household who buys a low energy house).

Besides this partnership strategy “Maisons MACCHI” has decided at the end of 2008 to create an affiliate called “MACC3” in charge of the marketing and distribution of the prefabricated elements. The creation of “MACC3” intends to improve the commercial visibility of the product and to separate two activities (the construction of individual houses and the manufacturing and distribution of the prefabricated concrete elements) which do not require the same competences and are not directed toward the same customers.

4.4 BoKlok

BoKlok is a concept developed by IKEA and Skanska in 1996 focusing on low and middle income households. Both companies identified a market for new and affordable housing in Sweden. Based on user involvement and analysis of users, houses for prefabrication was designed and produced. The first apartment buildings were built in Sweden in 1997. Since then the concept has been exported to the other Nordic countries (in 2002 – 2003) and the United Kingdom (2006/2007). Skanska as a

contractor and IKEA as a company developing and selling home furnishing had complementary and dissimilar activities but were pursuing similar objectives. They were competing on different markets. It facilitated the cooperation. IKEA, had long been looking for a partner in the building industry to help build new homes for low and middle income households. Skanska wanted to become the first construction company in Sweden to create a broad product on the basis of an entirely new approach. Both companies covered competences on knowledge about designing and furnishing, and of fabrication and producing and handling construction.

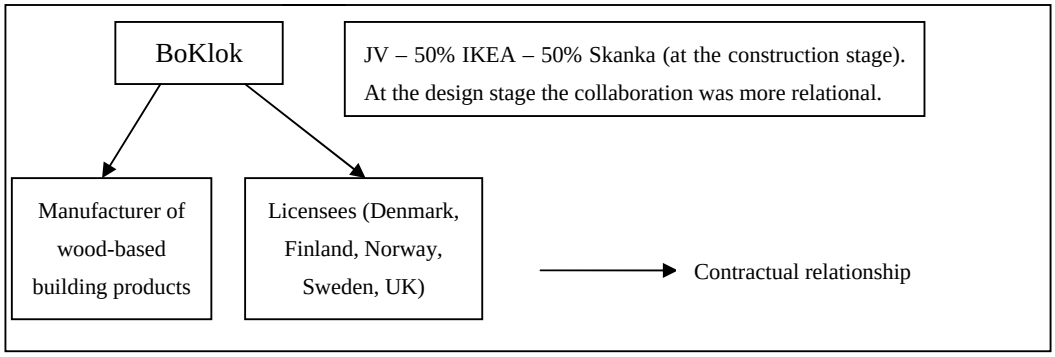

Figure 2: Nature of collaborative relationships between BoKlok and its partners

A marketing analysis indicated that the users wanted low price, did not want to live in high-rise blocks, but with access to neighbours and to green areas, a safe environment, light and airy, and use of natural materials. Also access to schools and public transportation was rated high. But the localisation did not need to be close to urban centres. Based on this information the IKEA team designed a compact living home for 1 to 3 people on 50 to 75 m2. After evaluating the project both company created a joint-venture in 2001. BoKlok is owned jointly by Skanska and IKEA (fig. 2)[2]. BoKlok AB is a concept company with its head office in Malmö, Sweden. It owns the brand and develops the successful business concepts. The company also awards licences, i.e. the right to build and sell BoKlok on a specific market.The licensee is granted the right to run the business under the BoKlok brand, and is given access to the licensor's know-how and administrative and commercial assistance. This means that collaboration between the license and the licensor is purely contractual while the collaboration between IKEA and Skanska is a mix of contractual and relational mechanisms.

The production of houses is done off-site. A factory is located in Sweden. Collaboration with Moelven, the leader of the Scandinavian market in wood-based building products, was established and a part of the deliverances of buildings still comes from this company.

[2] At Skanska it is a separate business unit (Residential Development Nordic) owned by Skanska that took over most of the activities.

Each license can develop its own strategy. For example in the UK, the companies that bought the right to build and sell BoKlok proposed a ”Try Before You Buy” scheme. It gives people the opportunity to rent a two-bedroom BoKlok apartment for a six-month period before buying the property outright. If they opt to buy their home their rental payments will be refunded, less a small administration fee.

The homes have been designed around factory processes that enable them to be far more efficiently constructed in quality-controlled conditions, than would be possible through traditional site based construction. They are constructed from timber frames and come with a host of standard features, including extra high ceilings and large windows for a light and airy feeling, laminated wood flooring, IKEA kitchens and huge balconies to upper floor flats. The buildings are transported in 3D to the site, where assembling and finishing takes place. At the end of 2009 about 4 000 apartments at over 100 locations in five different countries have been built.

5. Discussion and conclusion

The discussion examines the ways in which firms successfully collaborated with one another.

The aim of off-site industrialisation is to benefit from the efficiency associated to manufacturing (high volumes and reduction of production costs). In construction like in any other industry, the success of industrialisation requires more pre-planning on a project. Indeed any industrialised process does not accept changes as these changes are expensive once the manufacturing process has been launched. To limit the risks linked to changes collaboration between the stakeholders of a project is necessary at the design stage.

The three projects indicate that collaboration between various stakeholders was at the origin of the success of the three innovative projects. No single actor would have been able to achieve one of the three projects by relying on its own resources and competencies.

The group ACCOR collaborated at the design stage with a contractor. Because the uncertainty surrounding the project was very high, firms preferred to base their relationships on trust. Collaborative R&D requires trust to be efficient. Formal contractual relationships would have been inflexible to manage. Each actor brought its core competences: hotel trade for the client and construction for the contractor. Concurrent engineering was also developed. The contractor assigned a team of three employees at the design stage to coordinate the relationships with the finishing companies and the client. The stake of the collaboration consisted in optimizing the design of the hotel in order to industrialise the construction process and to limit the future exploitation costs.

The success of the renovation stage also resulted from the time spent at the design stage. Long term contracts were signed with contractors to favour communication and learning, develop the stability needed for exchange and enhance the efficiency of coordination. But learning effects were also optimised because the client drove the process. It coordinated the renovation sites and elaborated tools that favour learning.

Similarly the collaboration and technical assistance provided by the builder of individual houses ("Maisons MACCHI") to its manufacturer is a way to be sure that no bad surprise will be discovered on the building site. In the case of BoKlok lots of resources were also spent by IKEA and Skanska on design and on market studies to be sure that the concept that was developed would be profitable.

In the three cases the actors spent time and money at the design stage. This time was considered as an investment and not as a cost. In every case cooperation among actors took different forms. It was never purely formal or relational. There was always a mix of contractual and relational governance mechanisms. Collaboration became more formal once the projects became more stabilised. In the case of "HotelF1", arm's-length transactions were used instead of market transactions at the R&D stage. It promoted trust and learning among partners. Once industrialisation and construction were launched, contractual mechanisms became prevalent. Similarly IKEA and Skanska based their collaboration on trust at the R&D stage. Once the design phase was achieved and the project became closer to the market, a joint-venture was created.

To be successful the collaboration has to involve actors with complementary competences but also actors who follow different objectives:

- In the case of "HotelF1", the client wanted to create a new market and to fast become the leader of this market. The contractor who already had built several individual housings by using prefabricated panels, wanted to benefit from its competitive advantage and to diversify its market.

- In the case of BoKlok, IKEA is primarily interested in supplying low-budget solutions for housing. This is leverage for selling more furniture whereas SKANSKA is interested in a new and industrialised housing concept to lower construction cost in order to win market shares in the housing area.

- In the case of Maisons MACCHI, despite the small number of commands, the manufacturer expected to benefit in the long run from the development of a growing market. The house builder wanted to increase its share on the low energy houses market, to reduce the painfulness of the building site, to improve the productivity and to limit building misconception.

Industrialisation involves the rationalisation of the whole building process and no single actor can handle the whole process. Collaboration appears to be one of the key elements of industrialisation strategies because all the stakeholders involved during the course of a project need to share the same view over the project. Successful industrialisation requires integrating all the stakeholders of the building process at the beginning of the project. But to improve the efficiency and the quality of the construction process, cooperation needs a leading actor who drives and coordinates the process and coordinates the network of partners. The driving actor can be represented by two stakeholders who established a strategic and formal partnership (such as IKEA and Skanska in the BoKlok case).

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